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# Effect of voxels defragmentation on absolute permeability coefficients of porous media digital images calculated by navier-stokes equations and lattice boltzmann method

*Kazan Federal University, 420008, Kremlevskaya 18, Kazan, Russia*

## Abstract

© 2018, International Multidisciplinary Scientific Geoconference. All rights reserved. The flow properties of porous media play an important role in the study of hydrodynamic processes in oil and gas reservoirs. Such characteristics as absolute permeability coefficients, capillary pressure curves, relative phase permeability cannot be estimated from well logs and seismic survey. Their measurements in laboratory are time-consuming and cost expensive. An alternative approach for estimation flow properties is "Computational Rock Physics" using computational experiments on digital models of porous media, obtained from X-ray micro-CT, which often is the only means of their evaluation. To estimate the coefficients of absolute permeability using digital images, mathematical modeling methods are used, the most common of which are the Lattice Boltzmann Method (LBM) and the stationary Navier-Stokes equations (NSE). Based on the velocity field obtained as a result of the computational experiments, the permeability coefficient is estimated from Darcy's law. When calculating the permeability coefficients using the SRT-operator (Single-Relaxation time) within the LBM, the dependence of the permeability coefficients on the liquid viscosity was found. A series of computational experiments was carried out on 15 digital core models, comparing the flow characteristics obtained by the use of the MRT-operator (Multi-relaxation time) within LBM and the NSE. The results obtained indicate that the permeability coefficients calculated using the MRT-operator in LBM are on the average 20-25% higher compared to the solution of the Navier-Stokes equations. The specificity of digital models is the complexity of taking into account the influence of narrow pore channels, ranged in most cases from three to seven cells. To study the solution dependence on the spatial grid size, each cubic cell (voxel) of the digital model was split into cubic sub-voxels. The splitting along each side of the cube was two to eight times, so the maximum number of sub-voxels in one voxel was 512. It was found that the grid convergence of the results obtained in solving the NES is observed when voxels are split into more than 33 sub-voxels. When estimating the permeability coefficients by the use of the MRT-operator in the framework of LBM, the flow characteristics remain dependent on the voxels splitting even when they are split into 83 sub-voxels. When modeling flow processes using the SRT-operator in the framework of LBM, it was found that an increase the number of sub-voxels, i.e. reduction of the grid step, leads to a decrease in the dependence of the permeability coefficients on the viscosity.

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## Keywords

Lattice Boltzmann method, Navier-Stokes equations, Permeability, Voxel, X-ray CT

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